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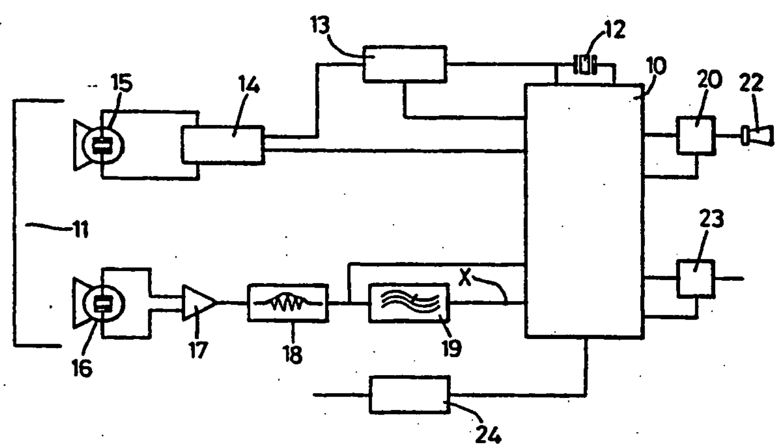

(57) Abstract

The device is primarily an anti-theft device or alarm for use in a vehicle and which can operate in a plurality of modes. The first mode may involve transmission of signals in the form of ultrasonic pulses from a transmitter (15) which are reflected from surfaces in the driver/passenger space (11) of the vehicle. The pulses are picked up by a receiver (16) and a pattern of reflections (34) is formed for comparison with a reference (33) based on the current level of background noise and environmental conditions in the space (11) and those associated with types of disturbance not intended to trigger an alarm. If an intrusion or disturbance occurs in the space which does not provide certainty that an alarm should be given, the device switches to a second mode where the transmitter (15) can transmit a continuous ultrasonic signal or a burst of ultrasound for a relatively long period. The reflected signal is picked up by the receiver (16) and compared to a reference level based on the current level of background noise and environmental conditions in the space (11) and those associated with types of disturbance not intended to trigger an alarm. If the reference level is exceeded an alarm is triggered. A third mode can be provided where there is no continuous or burst transmission from the transmitter and the system becomes passive so that the receiver (16) can pick up noise of breaking glass (Fig. 5).

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A DEVICE FOR AND METHOD OF SURVEILLANCE OF A SPACE

The invention relates to a device for and method of surveillance of a space and is particularly, but not exclusively, concerned with an anti-theft device for a motor vehicle.

In particular, the invention is concerned with a device which makes use of a transmitter for transmitting a signal into a space to be monitored, the signal being reflected from the space and picked up by a receiver. The reflected signal is then processed to provide a reference. Where there is an intrusion into the space, the subsequent reflected signal will deviate from the reference and provided that there is a significant difference between the two signals the device will provide an appropriate indication such as an audible and/or visible alarm or electrical signal. Insignificant differences such as would be created, for example, by environmental changes will not normally be sufficient to trigger the indication.

In one type of prior system the signal is transmitted as a series of pulses which has a fairly low power consumption and enables moving objects to be detected. However, with such a system coverage is restricted to a defined area, it does not perform well where the space is defined by or includ s highly absorbent interiors, the

position of the transmitter and receiver is fairly critical for efficient operation, storing means for the reference requires a large amount of memory and it does not easily sense smaller and faster moving objects if environmental noise is significant. In another prior system, the signal is transmitted continuously and sets up a wave pattern in the space. With such a system there is a relatively greater coverage area, it is less sensitive to the nature of the space itself and its contents and can provide reliable sensing of fast moving objects. However the continuous transmission consumes more energy than intermittent pulses.

With prior art systems of either type, there are borderline areas where the system cannot differentiate between an intrusion which should trigger an alarm and a change which could be due to environmental variations. Increasing the sensitivity of the device can cause the device to be triggered by a change in temperature in the space, small moving objects such as flies and external noise. On the other hand, decreasing the sensitivity of the device renders the device incapable of sensing, say, the breaking of a window or the arm of an intruder reaching into the vehicle and stealing a small article.

One object of the present invention is to provide an improved device which will assist in overcoming the aforementioned problems.

According to one asp ct of the present invention there is provided a device for providing surveillance of a space comprising a transmitter and a receiver, the device being arranged to operate in a first mode in which the transmitter transmits a signal into the space which is reflected from a surface and picked up by the receiver, processing means for processing the received signal to provide a reference, comparator means for comparing a change in received signal with the reference and means for providing an indication when a significant change is detected, the device also being arranged to operate in a second mode in which the receiver picks up a different form of signal from the space for processing and comparison with a further reference such that where there is a change in the received signal which exceeds said further reference by a significant amount an indication will be given, a changeover from one mode to the other being effected when the said change in the one mode does not provide certainty that said indication should be given.

Therefore a device in accordance with the invention is advantageous over those of the prior art as it will switch from one mode to the other at times of uncertainty over whether or not an indication should be given so as to provide a double ch ck on conditions in the space.

In the second mode, the transmitter is preferably

arranged to transmit a different type of signal from that transmitted in the first mode. In that way the conditions in the space will be reflected differently to the receiver and so a borderline case of intrusion may show up more accurately as a result of one kind of transmission than under the other kind of transmission.

In the first mode, the transmitter may transmit its signal as a series of pulses, e.g. ultrasonic pulses. The pulses can then be reflected and picked up as a series of pulses by the receiver and processed to produce a reflection pattern. Processing means for doing that may comprise a first element such as a filter having a long time constant which will provide a reference pattern remaining substantially unaffected by sudden changes taking place within the space, and a second element such as a filter having a considerably shorter time constant which will produce a pattern responsive to sudden changes affecting the space. In that way, the first element can set up a long term pattern corresponding to the long term conditions within the space created by, e.g., positioning of normal surfaces and environmental effects and will up-date automatically as environmental changes take place. On the other hand, the second element will provide, for example, a rapid indication of the presence of another surface such as an intruder which will immediately affect the pattern processed by the second element so that when comparison is made with the reference pattern by a

detection algorithm a chang will be detected.

When transmitting the pulses, the receiver will pick up not only reflections from the space but will also be directly mechanically coupled to a certain extent through components on which both the transmitter and receiver are mounted. Also there will also be a certain amount of acoustic coupling directly from the transmitter to the receiver. Therefore, in order to prevent the effects of acoustic and mechanical coupling from affecting the reflected energy it is preferable that the subsequent pattern is compared with the reference pattern after a time lapse has occurred from the transmitted pulse, said time lapse being sufficient for a directly coupled signal from the transmitter to the receiver substantially to cease.

In accordance with a second aspect of the invention there is proposed a device for providing surveillance of a space comprising a transmitter for transmitting a signal as a series of pulses into the space, a receiver for receiving pulses reflected from a surface, processing means for processing the received signal to provide a reference pattern, comparator means for comparing the reference pattern with a subsequent pattern and means for providing an indication when a significant chang between the reference pattern and the subsequent pattern is detected, the subs quent pattern being compared with the

reference pattern after a time lapse has occurred from the transmitted pulse, said time lapse being suffici nt for a directly coupled signal from the transmitter to the receiver substantially to cease.

Preferably the timing between transmitted pulses is selected by the device such that a subsequent pulse is transmitted after and close to a point at which fluctuations forming part of the pattern produced by reception of the immediately preceding pulse substantially cease or at a predetermined time. Ideally, the subsequent transmitted pulse is transmitted at a point as close as possible to the termination of a reflected signal sampling period resulting from transmission of a previous pulse. In that way minimum and optimum timing between transmitted pulses can be achieved.

According to a third aspect of the invention there is provided a device for providing surveillance of a space comprising a transmitter for transmitting a signal as a series of pulses into the space, a receiver for receiving pulses reflected from a surface, processing means for processing the received signal to provide a reference pattern, the timing between transmitted pulses being sel ct d by th device such that a subsequent pulse is transmitted after and close to a point at which fluctuations forming part of the reference pattern

produced by reception of th immediately preceding pulse substantially ceases or at a predetermined time thereafter.

In the device according to the two immediately preceding paragraphs, it is preferred that the processed signal from the receiver is initially monitored by sampling the reflected signal so that after each or a selected transmitted pulse a comparison of amplitude and pulse position in the resulting pattern is made and the time between samples can then be brought forward until such a time that the comparison detects an amplitude variation or gradient change in the pattern resulting from a pattern fluctuation whereupon the time period between the samples is set accordingly. This will normally be performed when the system is initially switched on or when it is necessary to reset the system so that it effectively "reads" the space conditions and gradually reduces the timing between samples until the minimum time gap is obtained and the highest resolution is achieved.

In the second mode, the transmitter can be arranged to transmit its signal as a continuous signal or as a relatively long burst of predetermined duration which is reflected from a surface and picked up by the receiver for processing to provide said further reference as a reference level, said comparator means being arranged to compare the rec iv d and processed signal with said

reference level.

In the second mode, where the transmitter transmits its signal as a continuous signal or as a relatively long burst of predetermined duration, the frequency content of the amplitude modulated received signal or phase modulated received signal can be analysed to detect whether or not there has been any disturbance within the space. Moreover, the system can read the long term conditions within the space and detection algorithms can be adjusted to allow the device to accommodate different environmental conditions. This procedure will normally be carried out when the unit is initially switched on or when it is necessary to re-set the system.

Where the transmitter transmits pulses in the first mode and transmits a continuous signal or a relatively long burst of predetermined duration in the second mode, a device in accordance with the invention brings together in a single system the advantages of the prior art using transmitted pulses and the prior art using continuous transmission. Therefore, where there is an intrusion into the space with the system in a pulse transmission mode but the system is unable to detect with certainty if an alarm should be given, the device will switch to the continuous or burst transmitted signal mode so that the intrusion can be read using a different form of transmission.

As an alternative proposal, the rec iv r can become passive to rend r the device sensitive to a signal resulting from the sound of breaking or fracturing of brittle materials such as glass or high energy impacts on materials associated with the space.

The passive mode of the system is most useful as it enables the sound of breaking glass to trigger an indication such as an alarm where the breaking of the glass does not provide sufficient certainty in either of the other modes that an indication should be given.

According to a fourth aspect of the invention, a device for providing surveillance of a space comprises a transmitter and a receiver, the device being arranged to operate in a first mode in which the transmitter transmits a continuous signal or relatively long burst of a predetermined duration into the space which is reflected from a surface and picked up by the receiver, processing means for processing the received signal to provide a reference, comparator means for comparing a change in received signal with the reference and means for providing an indication when a significant change is detected, the device also being arranged to operate in a second mode in which the transmitter transmits a signal as a series of puls s which is reflected by a surface and picked up by the receiver from the space for processing and comparison with a further ref rence such that wh r

there is a change in the received signal which exceeds said further reference by a significant amount an indication will be given, a changeover from one mode to the other being effected when the said change in the one mode does not provide certainty that said indication should be given.

The device described in the above paragraph may also be arranged to be operable in a third mode in which no signal or is transmitted by the transmitter and the receiver becomes passive to render the device sensitive to a signal resulting from the sound of breaking or fracturing of brittle materials such as glass or high energy impacts on materials associated with the space.

If desired a plurality of transmitters and a plurality of receivers can be provided.

The system is ideally suited as an alarm system or anti-theft device for a motor vehicle.

The invention also includes aspects relating to a method of providing surveillance of a space.

According to a first method aspect there is provided a method of providing surveillance of a space comprising transmitting a signal into the space in a first mode for reflection, from a surface, receiving and processing the

reflected signal to provide a reference, comparing a subsequently received and processed signal with the reference and providing an indication when a significant change is detected and where said change does not provide certainty that said indication should be given the method includes selecting a second mode to cause a different form of signal to be transmitted, processing that signal to provide a further reference, comparing the received and processed signal with the further reference and providing an indication where the reference is exceeded by a significant amount.

According to a second method aspect there is provided a method of providing surveillance of a space comprising transmitting a signal into the space in a first mode for reflection from a surface, receiving and processing the reflected signal, to provide a reference, comparing a subsequently received and processed signal with the reference, providing an indication when a significant change is detected and creating a time lapse from cessation of the transmitted pulse to the time when a comparison with the reference pattern is made, said time lapse being sufficient for a directly coupled signal from the transmitter to the receiver substantially to cease.

Açcording to a third method asp ct there is provided a method of providing surveillance of a spac comprising transmitting a signal into a space in a first mode for

reflection from a surface, receiving and processing the reflected signal, to provide a reference pattern, processing the reference pattern to establish a point at which the reflected signal diminishes below a predetermined level and transmitting a subsequent pulse close to or at a predetermined time after the point at which the reflected signal diminishes below the said predetermined level.

Advantages of the foregoing method aspects will be apparent from statements of advantage relating to aspects of the invention set concerned with the device.

Fig.1 is a diagram depicting operation of one form of a pulse transmission prior device,

Fig.2 is a diagram depicting operation of a continuous or burst signal transmission device,

Fig.3 is a diagram depicting operation of a device in accordance with the present invention,

Fig.4 is a circuit block diagram showing the layout of a device in accordance with the invention,

Fig.5 is a circuit block diagram for a pulses transmission first mode of operation,

Fig.6 is a graph illustrating the way in which an ultrasonic pulse can set up a simple reflected signal within a space,

Fig.7 is a graph showing a more complex reflected signal as would be expected within the driver/passenger compartment of a vehicle,

Fig.8 is a graph showing the way in which a time lapse is defined between transmission of a pulse and the monitoring of the reflected signal,

Fig.9 is a graph showing the way in which the system, when setting up initially, gradually reduces the timing between samples to an optimum,

Fig.10 is a graph showing the relation between environmental noise and noise caused by, say, intrusion or the like which could give rise to an alarm condition,

Fig.11 is a circuit block diagram for a continuous or burst transmission for the second mode of operation,

Fig.12 is a graph showing a steady state received signal in response to the continuous transmission,

Fig.13 is a series of graphs illustrating the processing

of received signals in the second mode of operation,

Fig.14 is a graph showing various curves relating to signals received in the second mode,

Fig.15 is a graphical representation of a sound pulse resulting from a glass window being broken, and

Fig.16 is a circuit block diagram for a passive mode of operation.

With reference to Figs.1 and 2, current anti-theft devices for use in vehicles and which use an ultrasonic transmitter signal use either the transmission of ultrasonic pulses P1 as in Fig.1 from a transmitter T1 (referred to herein as time domain) or use a continuously transmitted signal P2 as in Fig.2 from a transmitter T2 (referred to herein as frequency domain).

A time domain operation as in Fig.1 is suitable for sensing movements within a defined space in the vehicle but may not detect, for example, the insertion into the vehicle of an arm of an intruder and the removal of small objects where the intrusion is shielded by, for example, seating in the space.

A frequency domain system as in Fig.2 is aimed primarily

at sensing fast movements within the vehicle and, therefore, may fail to sense accurately the gradual opening of a window or door and the gradual entry of an intruder into the vehicle.

Neither domain is ideal for accurately detecting the breaking of a car window.

In accordance with one aspect of the present invention it is proposed to provide a more accurate and anti-theft device which combines at least one of the time domain TD and frequency domain FD modes with a passive mode PD. Fig.3 shows a combination of all three modes.

In that way, the advantages of the time domain and/or frequency domain systems are present in a single anti-theft device with the additional advantage of glass breakage detection in the passive mode as will be described later. Moreover, in accordance with the present invention, it is proposed to monitor environmental changes which affect the space and adapt the device accordingly to take those changes into account thereby adding a dimension EC to Fig.3.

Fig.4 is a block diagram of the device from which it will be se n that the device is under the overall control of a microprocessor 10 which is programmed with algorithms

for performing calculations associated with the transmitted and received signals. The microprocessor may incorporate on-chip peripheral devices such as an analogue-to-digital convertor. The microprocessor 10 has a clock signal generated internally with a crystal 12, or ceramic resonator, the signal being processed by a divider 13 to produce, for example, a 40KHz square wave for driving a push-pull output stage 14. The push-pull output stage drives a transmitter 15 and the microprocessor 10 controls the divider 13 and the push pull driver 14. This allows the transmitter 15 to be turned off and the output power from the transmitter to be reduced by switching from push-pull output stage into a single sided driver.

An output signal from the transmitter 15 is directed into a space 11 and reflections of the signals are picked up by a receiver 16. The output from the receiver 16 will normally be only a few millivolts and will require substantial amplification before it can be used by the microprocessor 10. Therefore, an amplifier 17 amplifies the signal from the receiver to a suitable voltage level for an amplitude de-modulator 18 which produces a DC voltage related to an envelope of the 40KHz reflected waveform. The output from the de-modulator 18 is passed directly to the microprocessor 10 and also to a second order low pass anti-aliasing filter 19. The cut off

frequency for the filter 19 is determined according to the maximum sampling rate of an analogue to digital converter in the microprocessor 10 and the bandwidth required. The gain of the amplifier 17 is controlled by the microprocessor 10 in addition to varying the transmitter output. In that way, the optimum signal can be obtained without signification degradation of the signal to noise ratio.

An input/output port 20 is provided in the microprocessor 10 for an alarm 22. A further output port 23 may be provided for communication through a line with other anti-theft modules in accordance with the invention.

The receivers of the modules could either be switched on together to monitor the complete field over a large volume or selected receivers could be activated to look at specific regions covered by associated transmitters. This feature is useful in that it will allow comprehensive coverage, say, of a complete vehicle irrespective of size and internal configuration. A vehicle such as a cross-country four-wheel drive type may be too large for a single transmitter/receiver arrangement to cover the complete interior of the vehicle in a satisfactory manner. Two interconnected modules could then be useful and could operate s quentially so that the signal from the transmitter of one module of the

system would not interfere in any way with the transmitted signal from the other.

In addition or as an alternative to the line from the input/output port 23 providing communication with a further module of the device, the line could interface the device with any other compatible ECU on the vehicle for either enhanced performance or on-board diagnostics. Alternatively, the line from the input/output port 23 could be used as a digital switch input or low current open collector output for switching small loads.

Under all modes of operation, the input/output ports 20, 23 will be protected against damage by misconnections and adverse operational conditions.

The system is driven by a suitable voltage supply which is controlled by a voltage stabiliser 24.

In order to improve coverage of the vehicle, a multiplexer (not shown) may be arranged between the transmitter 15 and receiver 16. Since suitable transmitters and receivers are similar in construction and performance, a microprocessor could be arranged to select which transducer will be the receiver or transmitter. Since the transducers would not produce identical field patterns when transmitting, the coverage

of the vehicle interior would be more comprehensive.

TIME DOMAIN MODE

When operating in the time domain mode, the transmitter 15 transmits a short ultrasonic signal into the vehicle and the signals are reflected from the vehicle interior to be picked up by the receiver 16.

Reference is now made to Fig.5 where point X corresponds to point X indicated in Fig.4.

From point X incoming signals are applied to a first filter 30 having a long time constant and a second filter 32 which has a considerably shorter time constant.

The filter 30 is referred to herein as a "reference filter" and the filter 32 is herein referred to as the "live filter".

The reference filter provides a reference pattern 33 which gives a long term pattern of the prevailing conditions of the vehicle interior. As environmental changes such as increases in temperature will have an effect on the system and bearing in mind that the increase in temperature tak s place over a period of time, th referenc pattern will gradually change to tak

into account such temperature changes. Also, if other environmental variations occur, for example a change in weather conditions leading to wind blowing over the vehicle, the reference filter will take that into account.

Therefore, by use of the reference filter, the system automatically adjusts itself for long term environmental changes.

The live filter provides a live pattern 34 which changes rapidly in response to any variation in signals picked up by the receiver 16.

In a steady state condition where there is no intrusion in the space, the reference and live patterns 33, 34 will correspond to each other and the difference between them sensed by a subtractor 35 which tends towards zero. Where there is a change in the live pattern, a difference in output will be sensed by the subtractor 35 and the output of the subtractor is then integrated by an integrator 36 and passed to an integrator comparator 36a which receives a threshold level from microprocessor software 37. The output from the integrator comparator 36 is then passed to an integrator output processor 38 which triggers the alarm 22 when the difference between the reference and live patterns is significant.

The interior of the vehicle will generally be constructed from various mat rials that exhibit different levels of absorption and reflection of ultrasonic energy. Therefore, the transmitted ultrasonic signals will result in reflections scattered around the interior of the vehicle to provide a unique reflected pattern for any particular set of vehicle conditions.

Reference is made to Fig.6 which shows (in upper graph A) a burst 39, e.g. 40kHz, of ultrasonic sound. Graph B shows the amplitude of the simple reflection of the ultrasonic burst indicating primary and secondary reflections E1, E2. The second reflection E2 could be produced by the primary reflection E1 after it has travelled around the vehicle interior again. For hard flat surfaces like glass and smooth plastics, the loss of ultrasonic energy at the surface will be small whilst softer materials such as upholstery and leather will result in a greater loss of transmitted ultrasonic energy. Therefore, the normal pattern of reflected energy will be more complex than that shown in Fig.6 and is more likely to be somewhat as shown in Fig.7.

In Fig.7, the complex reflected pattern has several peaks each of which will be generated by a pulse 39 reflecting off one or more surfaces before it reaches the receiver 16. The amplitude and time spacing of the received

reflected signals are depend nt on materials in the vehicle and the distance the pulse has to travel. As the distance between the transmitter and material from which this signal is reflected increases, the interval between the transmitted and received pulse increases and will lead to increased attenuation of the signal. In practice, the device can be tuned to detect reflected signals which reach the receiver 16 over a particular time so that, for example, a reflected signal reaching the receiver outside that time setting will be ignored for the purposes of analysis. With a narrow transmission pulse 39, the corresponding received pulses are found to be well defined and of similar widths as apparent from Fig.6.

If desired, the transmitted pulse width W can be either increased or decreased to provide the optimum amplitude of received signals and to control the number of detectable reflected pulses e.g., as shown in Fig.6. However, if the pulse width is increased excessively, multiple reflections or echoes may be produced and so for optimum operation in the time domain mode, the transmission pulse width is selected to give the best compromise between the amplitude of the received signals and the definition of received signal pulses.

In addition to varying the width of the pulse 39, it has

been found that a similar effect on the received signals can be achiev d by varying the amplitude of the transmitted signal. The transmitted pulse 39 will be quickly attenuated as it moves towards and strikes surfaces. Therefore, a low amplitude transmission may result in detectable reflection from low loss surfaces only where they are close to the transducers 15, 16. By increasing the amplitude of the pulse 39, a better coverage of the vehicle interior can be attained and a greater reflected signal to environmental noise ratio achieved. However, excessive increase in transmitted pulse amplitude can again result in a less stable reflected pattern as one or more of the reflected pulses may combine to either reinforce or cancel out the received reflected signal depending on the phase of the transmitted pulse. Therefore, the transmitted pulse is controlled so that the amplitude and pulse width are selected to give the best compromise.

When the transmitter 15 transmits the pulse 39 into the vehicle, there will be a certain amount of acoustic coupling where the receiver 16 picks up some of the ultrasonic signal directly from the transmitter 15 (acoustic coupling) and there will also be a certain amount of mechanical coupling through common mounting structure for the transmitter 15 and receiver 16. The signals picked up by the receiver 16 due to the acoustic

and mechanical coupling will normally be receiv d fractionally before the reflected signals begin to reach the receiver. Therefore, to prevent the effects of acoustic and mechanical coupling from distorting the live pattern 34 generated by reflected signal, it is proposed to delay onset of sampling the received signals to give time for signals over period M resulting from the acoustic and mechanical coupling to attenuate. Such timing is illustrated in Fig.8 where there is a time delay T from the cessation of the transmitted pulse 39 to the start of a sampling period P. The time delay T will be calculated by the microprocessor 10.

Once the initial pulse width, amplitude and period T have been set, then the sampling period P can be determined by monitoring the received signal for a pre-determined period after which the reflected signal substantially attenuates. For a range of vehicles, the maximum time taken for a pulse 39 to be transmitted and reflected from primary surfaces e.g. front and rear screens, can be calculated for determination of the maximum sampling period P.

When the system is initial setting after being switched on, the sampling period P can be set to correspond to the maximum time calculated for the transmission, reflection and reception of a pulse in the vehicle. After a

reflection pattern has been digitised and stored in the system, it may well be possible to reduce the sampling period P for a particular vehicle and environment and that is achieved by taking the difference between the last two sampled points x1, x2 in Fig.9 in a reflected image pattern each time the sampling period is changed and tests made, for a change in amplitude resulting in a change of gradient in the reference image 33. During the period marked S in Fig.9, there is no gradient change as the reflections have attenuated. The next pulse 39' is then brought forward to test for a gradient change between x2 and x3 and so on until during period S' a change in gradient due to a final pattern fluctuation F will be sensed and the sample period thereby defined. Thereafter a pulse is transmitted as close as possible to the end of the sampling period. By that method, there is a minimum amount of what can be term "dead time" between the attenuation of pattern fluctuations and the transmission of the next pulse 39.

Fig.10 is a graph of probability P against signal intensity I and serves to illustrate the difference between possible disturbance conditions e.g. due to environmental effects, and conditions where the system is either confident or not confident to trigger the alarm.

In Fig.10, a curve N1 illustrates distribution of long term environmental noise which would be register d by the reference filter 30 and the curve N2 represents the distribution of noise which leads to the triggering of an alarm condition and is programmed into the microprocessor 10. Therefore, the curve N2 is predetermined whilst the curve N1 varies depending on environmental changes.

Where the difference between the live and reference images 33 and 34 produces a difference which lies within zone C of curve N2 the system will trigger an alarm condition. However, the system is set to provide a reference level indicated by zone R providing a low confidence zone in which the system may not clearly discern between environmental noise and deviation from a steady state condition due to an intrusion. Where the difference between the reference and live images 33 and 34 results in a signal falling within zone R, the system is arranged to switch over to the frequency domain mode to enable the space 11 to be monitored using a different form of transmitted signal which may then provide certainty over whether or not an alarm should be triggered.

FREQUENCY DOMAIN MODE

The fr quency domain uses a continuously transmitted

signal of, e.g., ultrasound, or a burst of e.g., ultrasound which is substantially longer than that of a pulse used in the time domain mode to set up a field within the vehicle interior.

With reference to Figs.11 to 13, point X in Fig.11 corresponds to point X in Fig.4. The signal picked up by the receiver 16 passes through a high pass filter 40, through an integrator 42 and through an integrator output processor 43 to provide a demodulated constant DC level 44 at a steady state condition in the space 11. The DC level reflects the amplitude of the signal picked up by the receiver 16 and will vary with, for example, environmental changes. Preferably, the integrator 42 and integrator output processor 43 are the same components as components 36 and 38 in Fig.5 so that common components are used as far as possible for time frequency domain modes. A timing control 41 is provided.

When the ultrasonic field is disturbed, the amplitude of the received signal will be modulated by the changes in absorption, reflection and dispersion of the ultrasonic signal. The frequency content of the de-modulated received signal will be dependent upon the disturbance of the ultrasonic field. For example, low speed movement of air or surfaces within the space will result in low frequ nci s as shown in graph A2 of Fig.13 (showing

amplitude a against time t graphs) while rapid movements will generate higher frequencies as shown in Fig.13 graph A1. The signals shown in graphs A1 and A2 are rectified as shown in graphs B1 and B2 in Fig.13 and are then demodulated and integrated to provide a final signal C which is compared to a calculated threshold dependent on conditions in the space 11 and the difference will be used to trigger an alarm where the difference is significant.

The size of the disturbance will have an effect on the received signals because the reflection patterns which are set up in the vehicle will normally be constructed from a large number of individual reflected wave fronts. The resultant wave at the receiver 16 will change in amplitude and phase with respect to the transmitter when some or all of the wave fronts generated by the transmitted signal are disrupted from their normal paths.

There will be a phase relationship between the received signal and transmitted signal which contains similar information to the amplitude modulated signal as shown in Graphs A1 or A2. The phase modulated signal can be processed in a similar way to provide a measure of any disturbance in the space 11.

Fig.14 illustrates various frequency domain response

curv s which help to show the area in which the frequ ncy domain mode can be usefully appli d during operation of the device. The curves represent amplitude of the received signal d against frequency f.

Curve A illustrates the frequency domain mode spectrum of background noise. Curve B shows the spectrum of vehicle cooling. Curve C shows the spectrum of a slow movement of an arm reaching into and removing a small item from a seat of the vehicle and curve D shows the spectrum of simulated external wind blowing over the vehicle air intakes. It can be seen that for slow intruder movements, thermal effects and external wind blowing over the air intakes of the vehicle, the differences in response are relatively small and could easily be confused with each other. However, curves E, F and G show respectively typical normal movement inside a vehicle, normal door opening and closing and what could be regarded as normal movement through a vehicle window. In the latter case, the movement represents an intruder reaching in and removing a small item from the seat over a total time of approximately 3 seconds.

Therefore, it can be clearly seen that where conditions E, F and G prevail, the frequency domain mode normally can readily distinguish such conditions from both the background condition and environmental effects. The

region between the two sets of curves is well defined in Fig.14. However, with different vehicles; the environmental response may increase in both frequency content and amplitude with adverse external conditions.

To extract information from the frequency domain signal, it is necessary to filter out the low frequency noises where all of the curves lie in close proximity. It is, therefore, proposed to provide a filter 40 having a characteristic curve H as shown in broken lines in Fig.14. After filtering the signal from the detector 18, the intruder related frequencies can be analysed to determine the duration and size of the disturbance and compared with background reference levels. Where the difference is significant an alarm condition will be given.

When the system is disturbed either in the time domain mode or the frequency domain mode, the breaking of a window in the vehicle or a high intensity impact, may not have an effect on the reflected signal sufficiently significant to take the system to the alarm state. Therefore, it is proposed to provide a passive mode sensing by disabling the transmitter 15 to allow the detection of high frequency impulses generated by, e.g., br aking glass.

PASSIVE MODE

For the passive mode, the transmitter 15 is switched off completely and the system monitors the receiver 16 for a short duration of high amplitude bursts as shown in Fig.15 which illustrates the shape of a curve representing the sound of breaking glass, as heard by the transducer 16, the curve being based on amplitude a against time t.

Reference is made to Fig.16 in which point X in the diagram corresponds to point X in Fig.4.

A signal picked up by the receiver 16 passes through a highpass filter 50, through an integrator 52 and an integrator output processor and comparator 53 which processes the input from the integrator 52. Also, the processor 53 provides an integrator re-set signal. Preferably, the same circuitry can be used for the time domain, frequency domain and passive domain modes of operation.

The impulse generated when the glass is struck may contain several large transient peaks and that could increase the possibility of the passive mode triggering a false alarm signal. To overcome this, the output from the detector 18 is filtered by filter 50 to substantially

remove the high frequency transient peaks thereby providing a smoothed envelope of the impulse. The output is then integrated and compared in the integrator output processor/comparator 53 with a simple reference level programmed into the microprocessor 10 to determine if an alarm condition has occurred. The system can be re-set after an alarm condition to allow it to re-arm without immediately false alarming.

One strategy for switching between all three modes is as follows :-

1. Enable the ultrasonic components of the system.
2. Enter Passive mode.
3. If an intrusion is detected with a high degree of confidence then raise an alarm and return to step 2.
4. If an intrusion is detected with a low degree of confidence then attempt to arm Time Domain mode.
5. If Time Domain mode is armed and an intrusion is detected with a high degree of certainty, then raise an alarm and return to step 2.
6. If Time Domain mode cannot be armed (i.e. is unstable) then attempt to arm Frequency Domain mode.
7. If Frequency Domain mode is armed and an intrusion is detected with a high degree of certainty then raise an alarm and return to step 2.
8. If Frequency Domain mode cannot be armed (i.e. is

unstabl) then enter Passive mode, only raise an alarm if an intrusion is det cted in Passive mode with a high degree of certainty and do not attempt to rearm either of the other modes.

In the event that a window is left open in the vehicle, the interior space 11 of the vehicle can become unstable due to movement of air through the space and both the time domain and frequency domain modes may not be able to operate accurately. That can lead to repeated switching between the time domain and frequency domain modes so that neither system can stabilise. Where a steady state condition cannot be achieved after a predetermined time programmed into the microprocessor 10, the system will switch to the passive mode so that transmission of ultrasonic signals from the transmitter 15 ceases. The system will then remain in the passive mode so that it will detect the sound of breaking glass even though it will not operate in the time domain or frequency domain mode. This is advantageous over prior art systems which rely either on a time domain or frequency domain principle where neither system would operate correctly during unstable conditions in the vehicle and which could prevent the system being correctly armed or could give rise to a false indication of intrusion.

In the event of a window being broken and particularly if

falling glass li s behind a shield such as a vehicle sheet, the time domain mode may not detect the breaking glass although it may well detect a deviation at the live filter 34. If the deviation is slight, it will cause the system to switch into frequency domain mode which should sense that a window has been broken as there will be a change in air pressure in the vehicle and movement of falling glass.

Whilst specific reference has been made to the system operating primarily in the time domain mode and then switching to the frequency domain mode to provide sampling where there is doubt over whether or not the intrusion could give rise to an alarm condition, it should be understood that the system could operate primarily in the frequency domain mode and then switch to time domain mode to validate an intrusion. In any event, where a first mode switches to a second mode for alternative signal sampling, the system will subsequently switch back to the initial mode for continued operation.

The system could be adapted such that it provides a two mode operation where in one mode the transmitter 15 transmits a signal for reflection and reception by the receiver 16, and where in the other mode the receiver becomes passive to enable breaking glass to be detected. E.g. the system operates primarily in the frequ ncy

domain mode and switches to passive mode.

The device can be switched remotely from a standby condition to an armed condition by using a hand held transmitter which emits an ultrasonic or other type of signal in the electromagnetic spectrum..

Instead of using the transmitter 15 to transmit an ultrasonic signal it could transmit an alternative radiated energy signal.

CLAIMS

1. A device for providing surveillance of a space (11) comprising a transmitter (15) and a receiver (16), the device being arranged to operate in a first mode in which the transmitter (15) transmits a signal into the space (11) which is reflected from a surface and picked up by the receiver (16), processing means (10) for processing the received signal to provide a reference, comparator means (35) for comparing a change in received signal with the reference and means (22) for providing an indication when a significant change is detected, the device also being arranged to operate in a second mode in which the transmitter (15) does not transmit a signal and in which the receiver (16) picks up a different form of signal from the space (11) for processing and comparison with a further reference such that where there is a change in the received signal which exceeds said further reference by a significant amount an indication will be given, a changeover from one mode to the other being effected when the said change in the one mode does not provide certainty that said indication should be given.

2. A device according to Claim 1 in which in the first mode the transmitter (15) transmits a signal as a series of pulses.

3. A device according to Claim 2 in which the receiver (16) picks up reflected pulses and the processing means (10) produces a reference pattern to which a pattern produced by subsequent reflected pulses is compared.

4. A device according to Claim 3 in which the processing means (10) includes a first element arranged to provide a reference pattern (33) which remains substantially unaffected by sudden changes taking place within the space (11) and a second element arranged to provide a pattern (34) which changes relatively quickly in response to sudden changes taking place within the space (11).

5. A device according to Claim 3 or 4 in which the subsequent pattern (340 is compared with the reference pattern (33) after a time lapse has occurred from the transmitted pulse, said time lapse being sufficient for a directly coupled signal from the transmitter (15) to the receiver (16) substantially to cease.

6. A device for providing surveillance of a space (11) comprising a transmitt r (15) for transmitting a signal as a series of pulses into the space (11), a receiver (16) for receiving pulses reflected from a surface, processing means (10) for processing the received signal to provide a reference pattern (33), comparator means (35) for comparing the reference pattern (33) with a subsequent pattern (34) and means (22) for providing an indication when a significant change between the reference pattern (33) and the subsequent pattern (34) is detected, the subsequent pattern (34) being compared with the reference pattern (33) after a time lapse has occurred from the transmitted pulse, the duration of the time lapse being automatically variable by the device and said time lapse being sufficient for a directly coupled signal from the transmitter (15) to the receiver (16) substantially to cease.

7. A device according to any of Claims 3 to 6 in which the timing between transmitted pulses is selected by the device such that a subsequent pulse is transmitted after and close to a point at which fluctuations forming part of the reference pattern (33) produced by reception of the immediately preceding pulse substantially ceases or at a predetermined time thereafter.

8. A device for providing surveillance of a space (11) comprising a transmitter (15) for transmitting a signal as a series of pulses into the space (11), a receiver (16) for receiving pulses reflected from a surface, processing means (10) for processing the received signal to provide a reference pattern (33), the timing between transmitted pulses being selected by the device such that a subsequent pulse is transmitted after and close to a point at which fluctuations forming part of the reference pattern produced by reception of the immediately preceding pulse substantially ceases or at a predetermined time thereafter.

9. A device according to Claim 7 or 8 in which the processed signal from the receiver (16) is initially monitored by sampling the reflected signal so that after each or a selected transmitted pulse a comparison of amplitude and pulse position in the resulting pattern is made and the time between samples can then be brought forward until such a time that the comparison detects an amplitude variation or gradient change in the pattern resulting from a pattern fluctuation whereupon the time period between the samples is set accordingly.

10. A device according to Claim 1 in which in the first mode the transmitter (15) is arranged to trânsmit its signal as a continuous signal or a relatively long burst of predetermined duration which is reflected from a surface and picked up by the receiver (16) for processing to provide said reference as a reference level, said comparator means (35) being arranged to compare the received and processed signal with said reference level.

11. A device according to any preceding Claim in which in the second mode the receiver (16) becomes passive to render the device sensitive to a signal resulting from the sound of breaking or fracturing of brittle materials such as glass or high energy impacts on materials associated with the space (11).

12. A device according to Claim 11 in which the mode in which the receiver (16) becomes passive is selectable where in a different mode the device is unable to provide certainty that said indication should be given.

13. A device according to any preceding Claim in which the device is operable in a third mode in which the transmitter (15) is arranged to transmit its signal as a continuous signal or a relatively long burst of

predetermined duration which is reflected from a surface and picked up by the receiver (16) for processing to provide said further reference as a reference level, said comparator means (35) being arranged to compare the received and processed signal with said reference level.

14. A device for providing surveillance of a space (11) comprising a transmitter (15) and a receiver (16), the device being arranged to operate in a first mode in which the transmitter (15) transmits a continuous signal or relatively long burst of a predetermined duration into the space which is reflected from a surface and picked up by the receiver, processing means (10) for processing the received signal to provide a reference, comparator means (35) for comparing a change in received signal with the reference and means (22) for providing an indication when a significant change is detected, the device also being arranged to operate in a second mode in which the transmitter (15) transmits a signal as a series of pulses which is reflected by a surface and picked up by the receiver (16) from the space (11) for processing and comparison with a further reference such that where there is a change in the r ceived signal which xceeds said further reference by a significant amount an indication will be given,

a changeover from one mode to the other being effected when the said change in the one mode does not provide certainty that said indication should be given.

15. A device according to Claim 15 in which the device is operable in a third mode in which no signal or is transmitted by the transmitter (15) and the receiver (16) becomes passive to render the device sensitive to a signal resulting from the sound of breaking or fracturing of brittle materials such as glass or high energy impacts on materials associated with the space.

16. A device according to any preceding Claim in which a plurality of receivers (16) is provided for picking up signals transmitted from one or more transmitters (15).

17. A motor vehicle having a device according to any preceding Claim for providing surveillance of a space (11) within the vehicle.

18. A method of providing surveillance of a space (11) comprising transmitting a signal into the space (11) in a first mode for reflection from a surface, receiving and processing the reflected signal to

provide a reference, comparing a subsequently receiv d and processed signal with th reference and providing an indication when a significant change is detected and where said change does not provide certainty that said indication should be given the method includes selecting a second mode in which a signal is not transmitted, picking up a different form of signal from the space (11) and processing that signal to provide a further reference, comparing the received and processed signal with the further reference and providing an indication where the reference is exceeded by a significant amount.

19. A method according to Claim 18 including transmitting the signal as a series of pulses.

20. A method according to Claim 19 including processing the received pulses so as to produce a reference pattern (33), and comparing the reference pattern (33) with patterns (34) generated by subsequent reflected pulses.

21. A method according to Claim 20 including processing the reflected pulses so as to provide a reference pattern (33) which is substantially unaffect d by sudden changes taking place in the space (11) and to

provide a further pattern (34) which changes relatively quickly in response to sudden changes taking place within the space (11).

22. A method according to Claim 20, or 21 including creating a time lapse from cessation of the transmitted pulse to the time when a comparison with the reference pattern (33) is made, said time lapse being sufficient for a directly coupled signal due to transmission substantially to cease.

23. A method of providing surveillance of a space (11) comprising transmitting a signal into the space (11) in a first mode for reflection from a surface, receiving and processing the reflected signal, to provide a reference pattern (33), processing the reference pattern (33) to establish a point at which the reflected signal diminishes below a predetermined level and transmitting a subsequent pulse close to a or at a predetermined time after the point at which the reflected signal diminishes below the said predetermined level.

24. A device according to Claim 22 or 23 including transmitting a subsequent pulse after and close to a point at which fluctuations forming part of the

pattern produced by reception of a preceding pulse substantially cease or at a predetermined time thereafter.

25. A method of providing surveillance of a space (11) comprising transmitting a signal into a space (11) in a first mode for reflection from a surface, receiving and processing the reflected signal, to provide a reference pattern (33), and transmitting a subsequent pulse after and close to a point at which fluctuations forming part of the reference pattern (33) produced by reception of a preceding pulse substantially cease or at a predetermined time thereafter.

26. A method according to Claim 24 or 25 including sampling the reflected signal after each or a selected transmitted pulse, comparing the amplitude and pulse position in the resulting pattern and bringing forward the time between samples until the comparison detects an amplitude variation or gradient change resulting from a pattern fluctuation, and setting the time period between the samples accordingly.

27. A method according to Claim 18 including

transmitting in the first mode a continuous signal or a signal comprising a relatively long burst of predetermined duration into the space for reflection, reception and processing to provide said further reference as a reference level, and comparing any change in level with said reference level.

28. A method according to Claim 27 including analysing the frequency content of the received signal when amplitude modulated or phase modulated.

29. A method according to any preceding Claim including operating the device passively whereby the different form of received signal will be a signal resulting from the sound of breaking or fracturing of brittle materials such as glass or high energy impacts on materials associated with the space.

30. A method according to any preceding Claim including operating the device in a third mode, third mode operation including transmitting a continuous signal or a signal comprising a relatively long burst of predetermined duration into the space for reflection, reception and processing to provide said further reference as a reference level and comparing any change in level with said reference level.

31. A method according to Claim 30 including selecting the third mode where the device is unable in a different mode to provide certainty that the said indication should be given.

32. A method of providing surveillance of a space comprising transmitting a signal as a series of pulses into the space in a first mode for reflection from a surface, receiving and processing the reflected signal to provide a reference, comparing a subsequently received and processed signal with the reference and providing an indication when a significant change is detected and where said change does not provide certainty that said indication should be given the method includes selecting a second mode, picking up a different form of signal from the space and processing that signal to provide a further reference, comparing the received and processed signal with the further reference and providing an indication where the reference is exceeded by a significant amount.

33. A method according to Claim 32 including operating the device in a third mode, third mode operation including transmitting no continuous signal or signal comprising a relatively long burst of predetermined duration and operating the device

passively whereby the different form of received signal will be a signal resulting from the sound of breaking or fracturing of brittle materials such as glass or high energy impacts on materials associated with the space.

34. A device for providing surveillance of a space (11) constructed and arranged substantially as described herein with reference to the accompanying drawings.

35. A method of providing surveillance of a space (11) substantially as described herein with reference to the accompanying drawings.

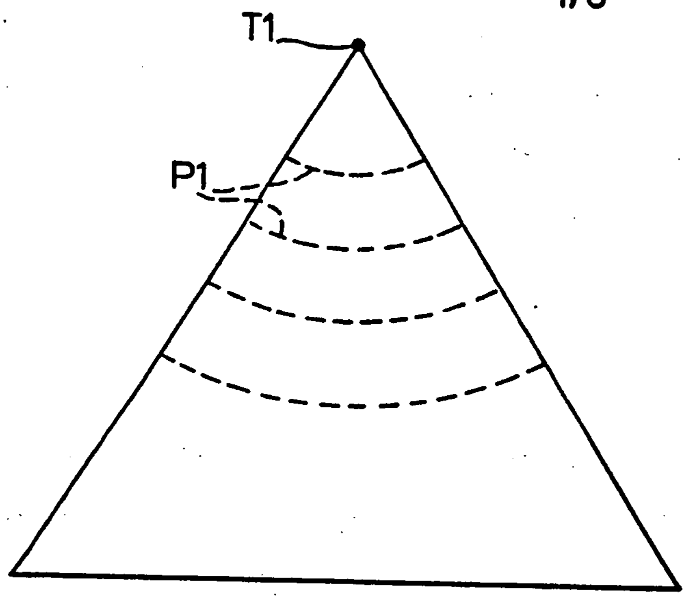

Fig. 1

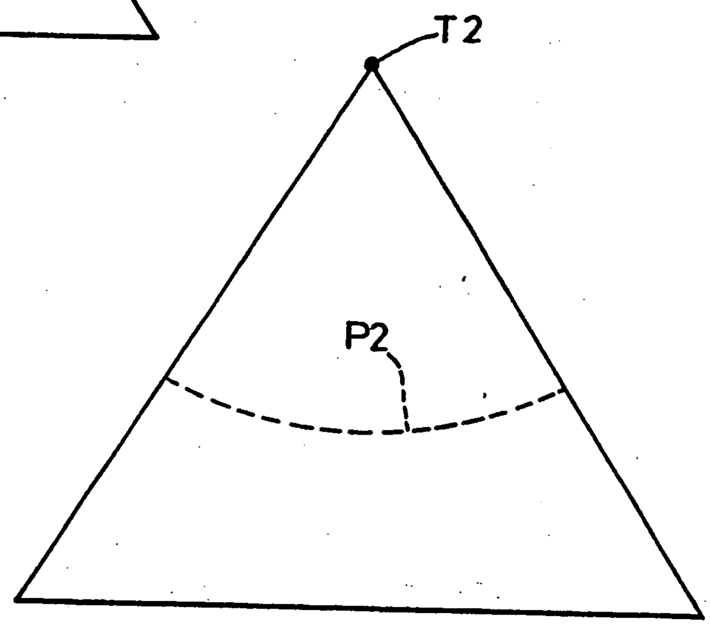

Fig. 2

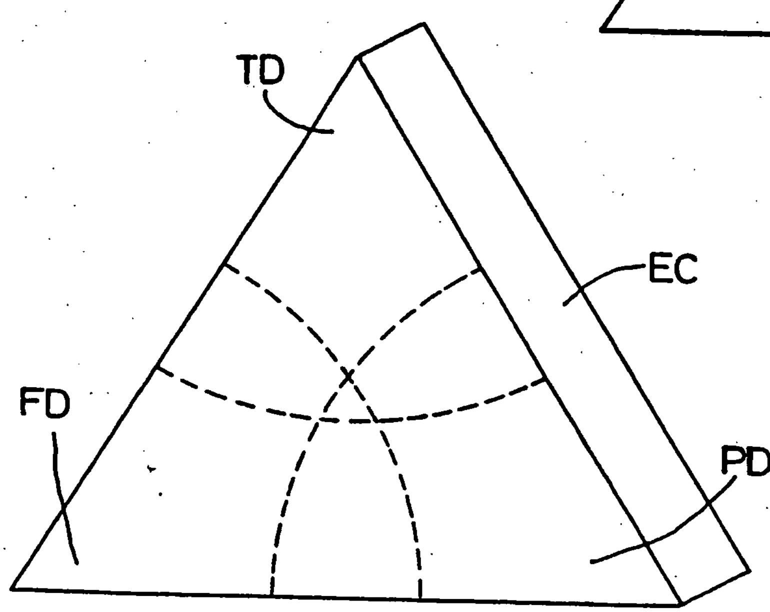

Fig. 3

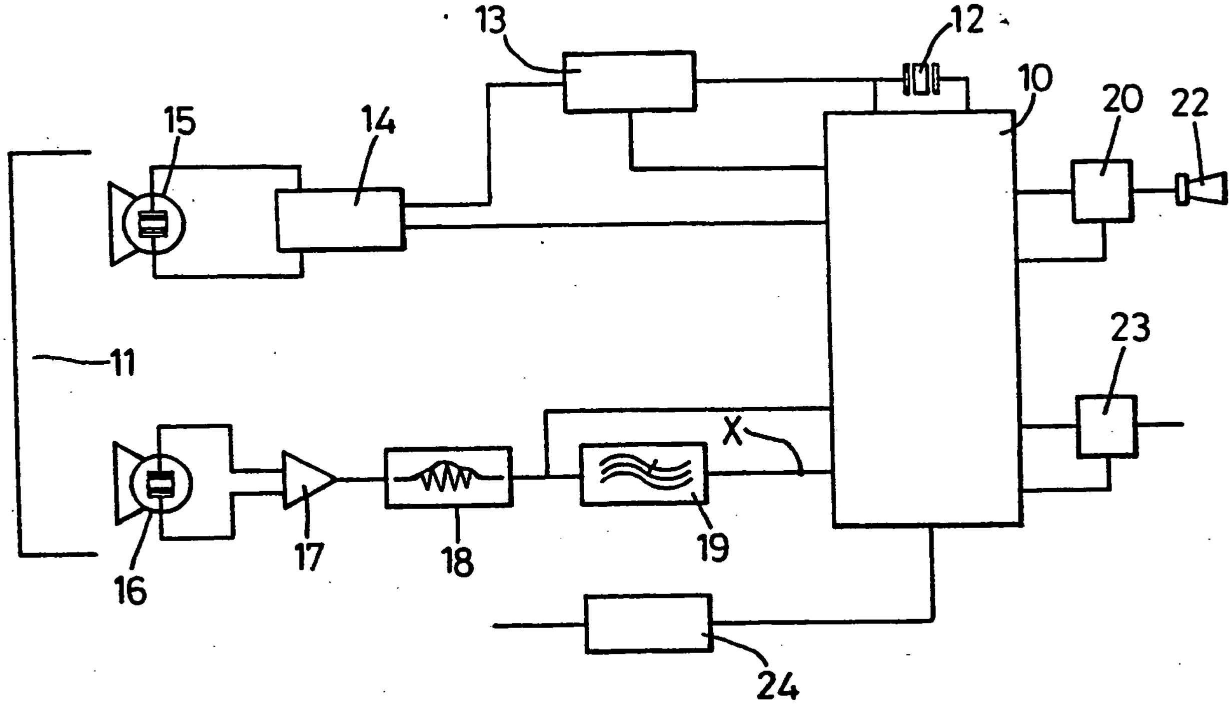
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Fig. 4

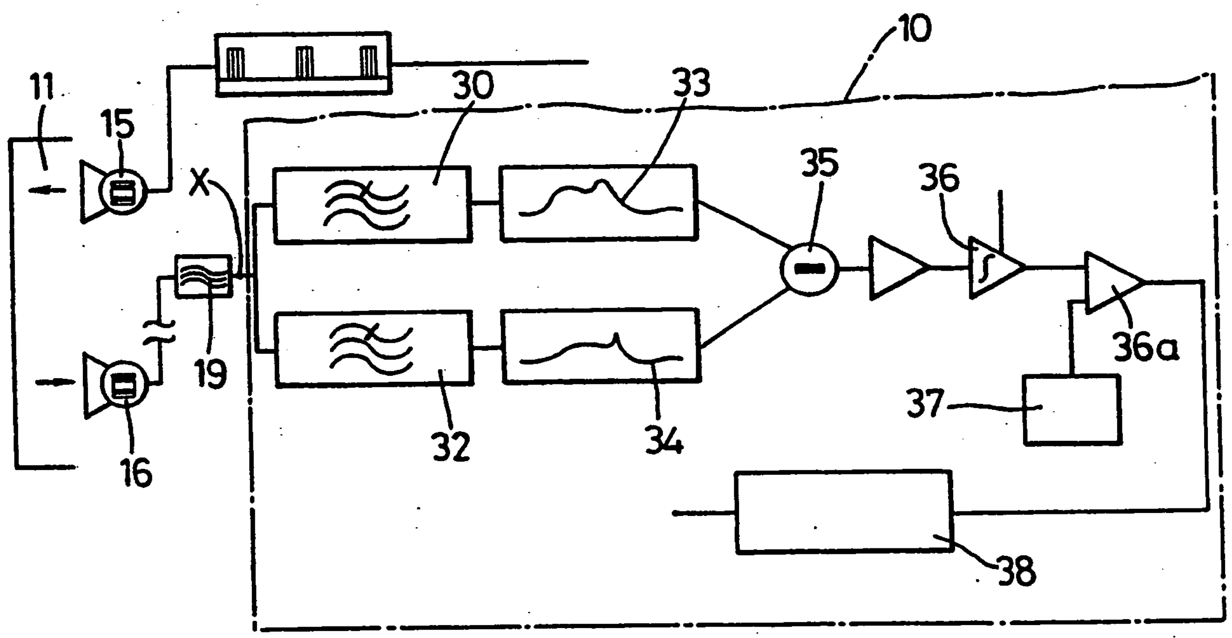
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Fig. 5

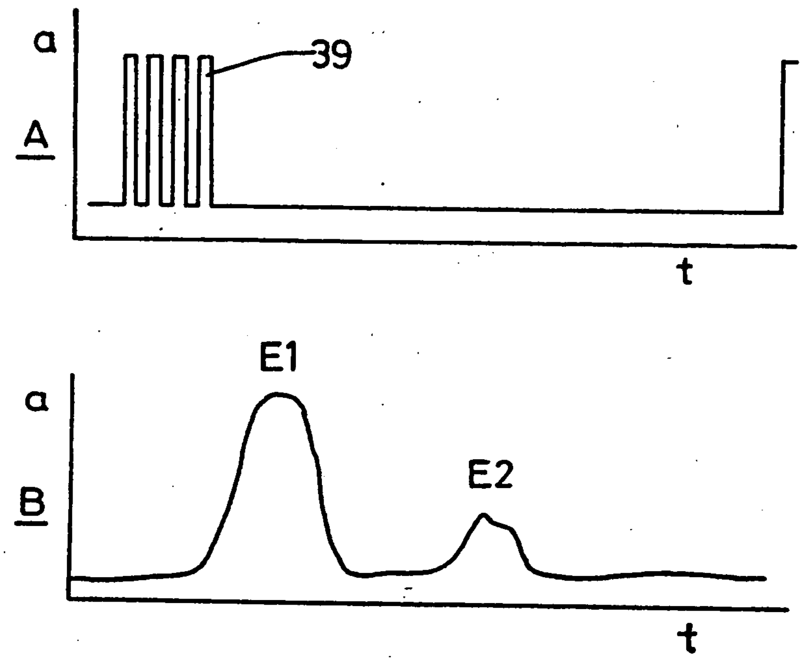

Fig. 6

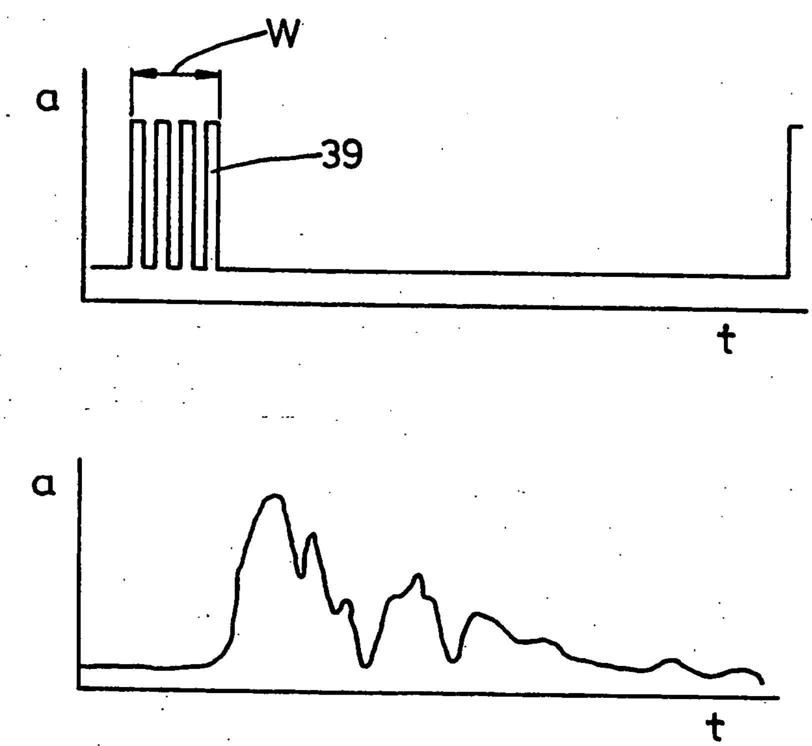

Fig. 7

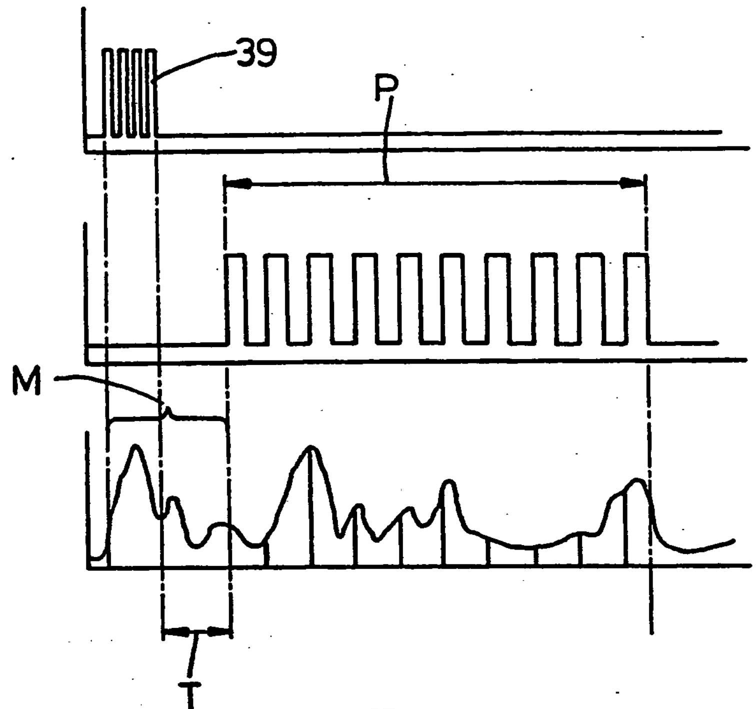

Fig. 8

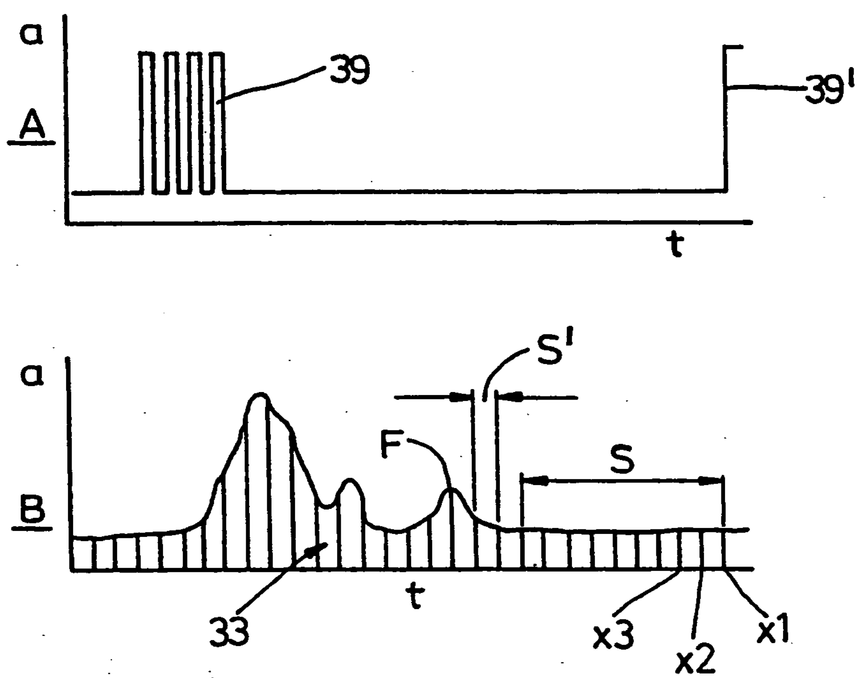

Fig. 9

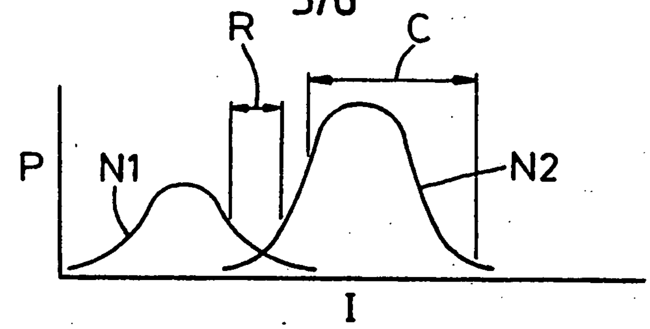

Fig. 10

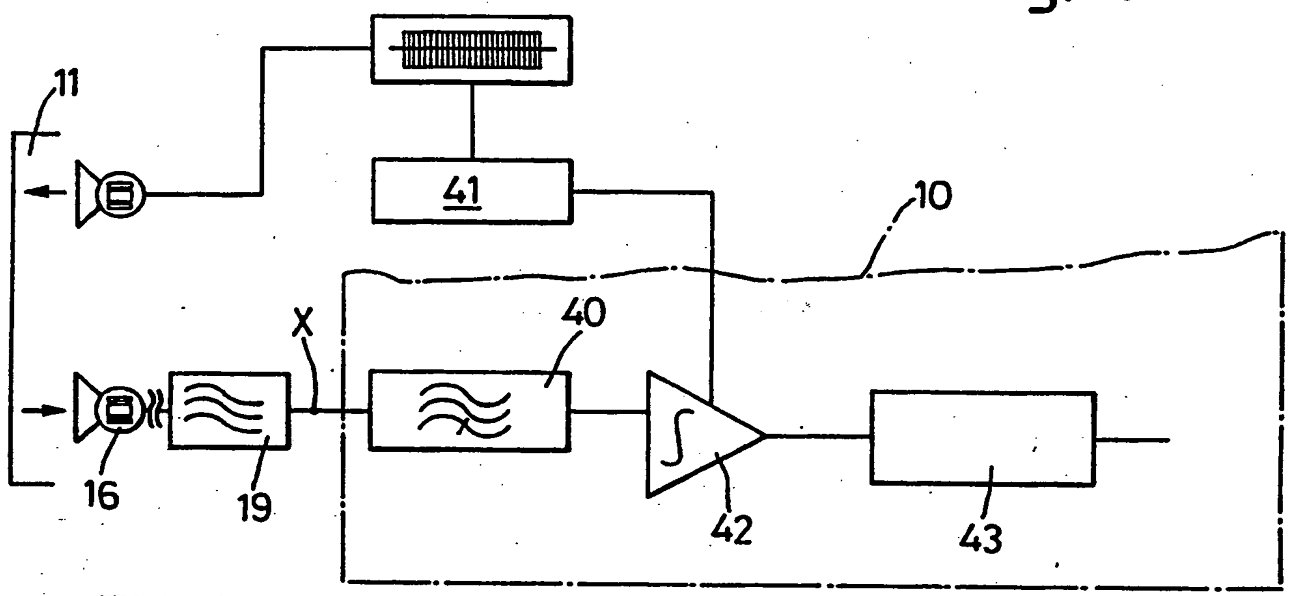

Fig. 11

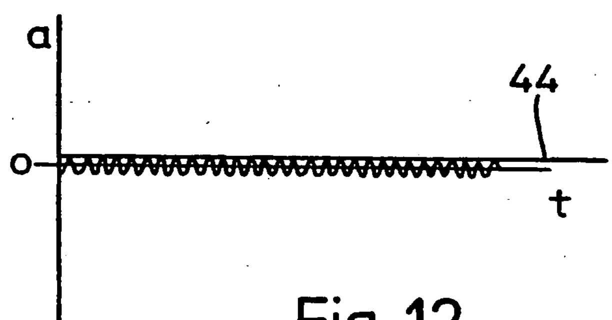

Fig. 12

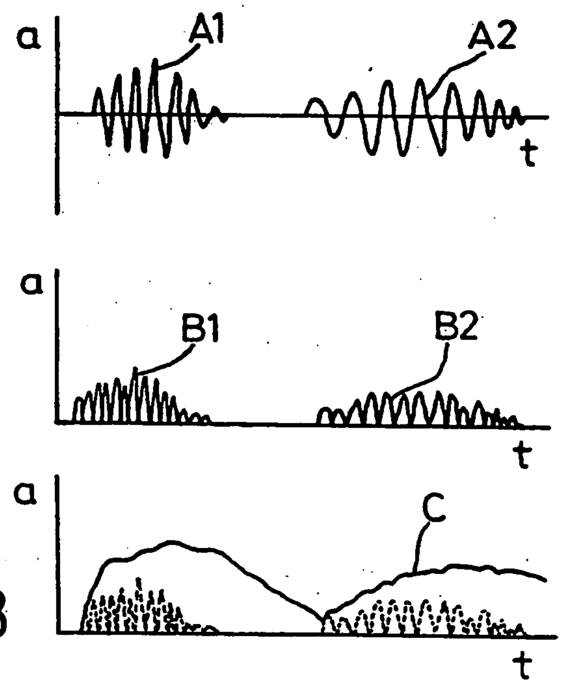

Fig. 13

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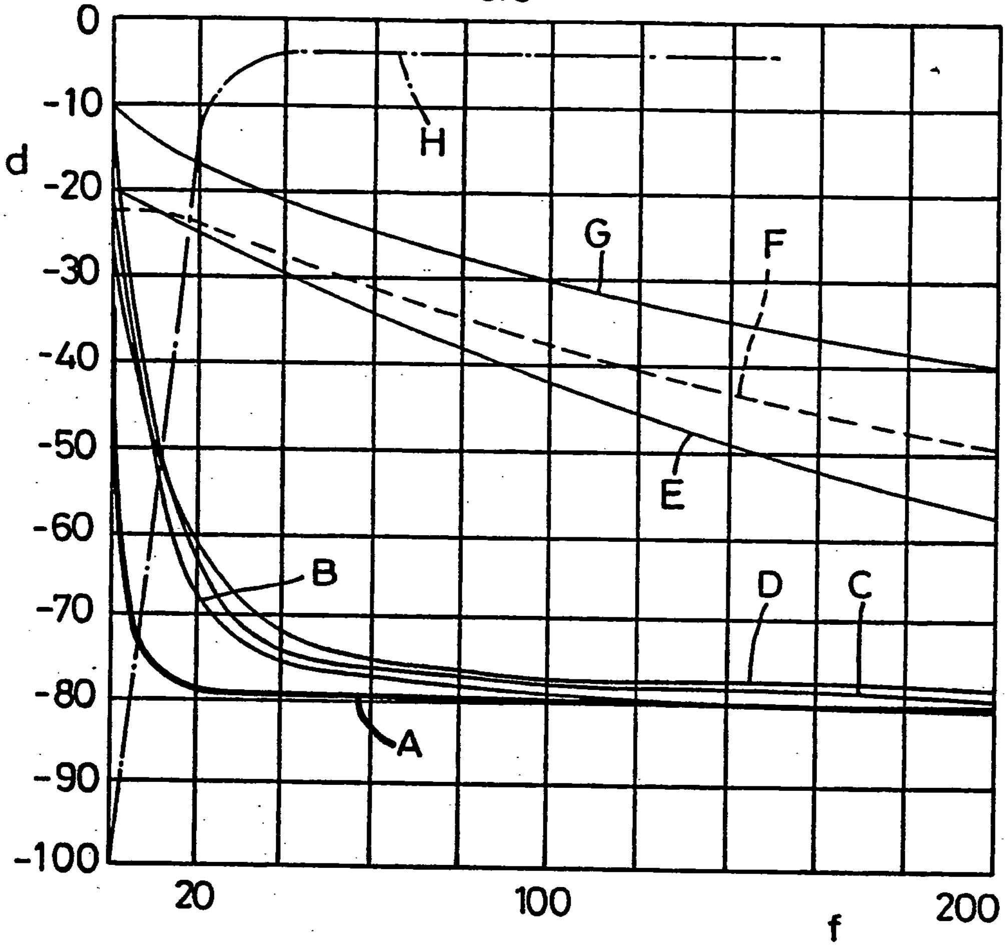

Fig. 14

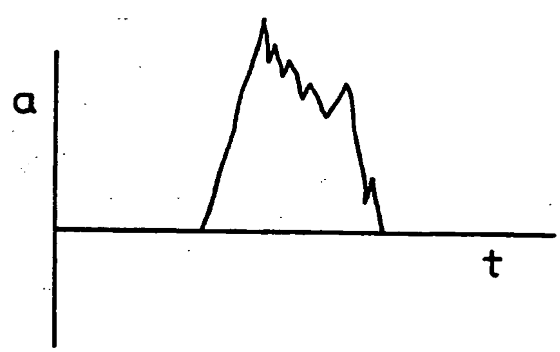

Fig. 15

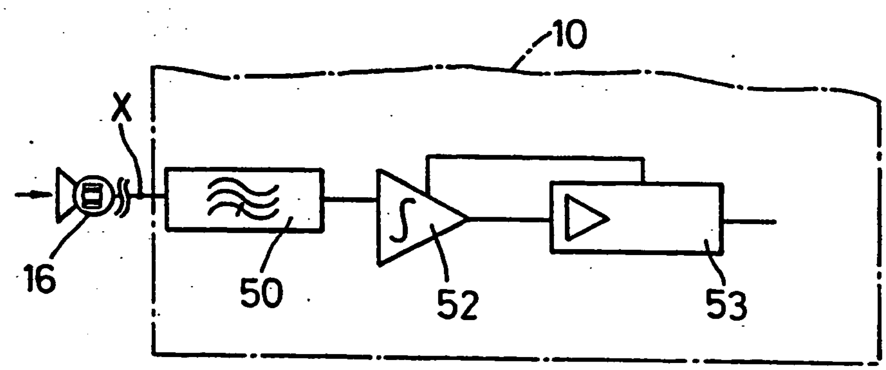

Fig. 16

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 93/00598

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G01S15/52; G01S15/04; G08B13/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G01S ; G08B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
Y	US,A,4 088 989 (SOLOMON) 9 May 1978	1-4,11, 15, 18-21, 27-29
A	see column 1, line 5 - column 2, line 55; figure 1	12,22, 31,33
Y	EP,A,0 473 835 (SIEMENS) 11 March 1992	1-4,11, 15, 18-21, 27-29
X	see abstract; figure 4	14,32
A		12,31,33
X	DE,A,3 226 517 (SIEMENS) 19 January 1984	6-8,10, 13, 23-25,30
A	see abstract; figures 1,2 see page 9, line 26 - page 10, line 14	5,22

-/--

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

1

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
28 JUNE 1993	07.07.93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	Francesco Zaccà

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	EP,A,0 368 303 (KABELWERKE REINSHAGEN GMBH) 16 May 1990 see abstract ---	17
A	EP,A,0 058 205 (SECOM) 25 August 1982 see abstract; figure 8 ---	3,4,20, 21
A	EP,A,0 233 390 (AUTOMATED SECURITY (HOLDINGS) LIMITED) 26 August 1987 see abstract -----	11,15, 29,33

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9300598
SA 73080

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 28/06/93
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4088989	09-05-78	None	
EP-A-0473835	11-03-92	None	
DE-A-3226517	19-01-84	None	
EP-A-0368303	16-05-90	DE-A- 3838150	31-05-90
EP-A-0058205	25-08-82	WO-A- 8200727 US-A- 4499564	04-03-82 12-02-85
EP-A-0233390	26-08-87	None	

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82